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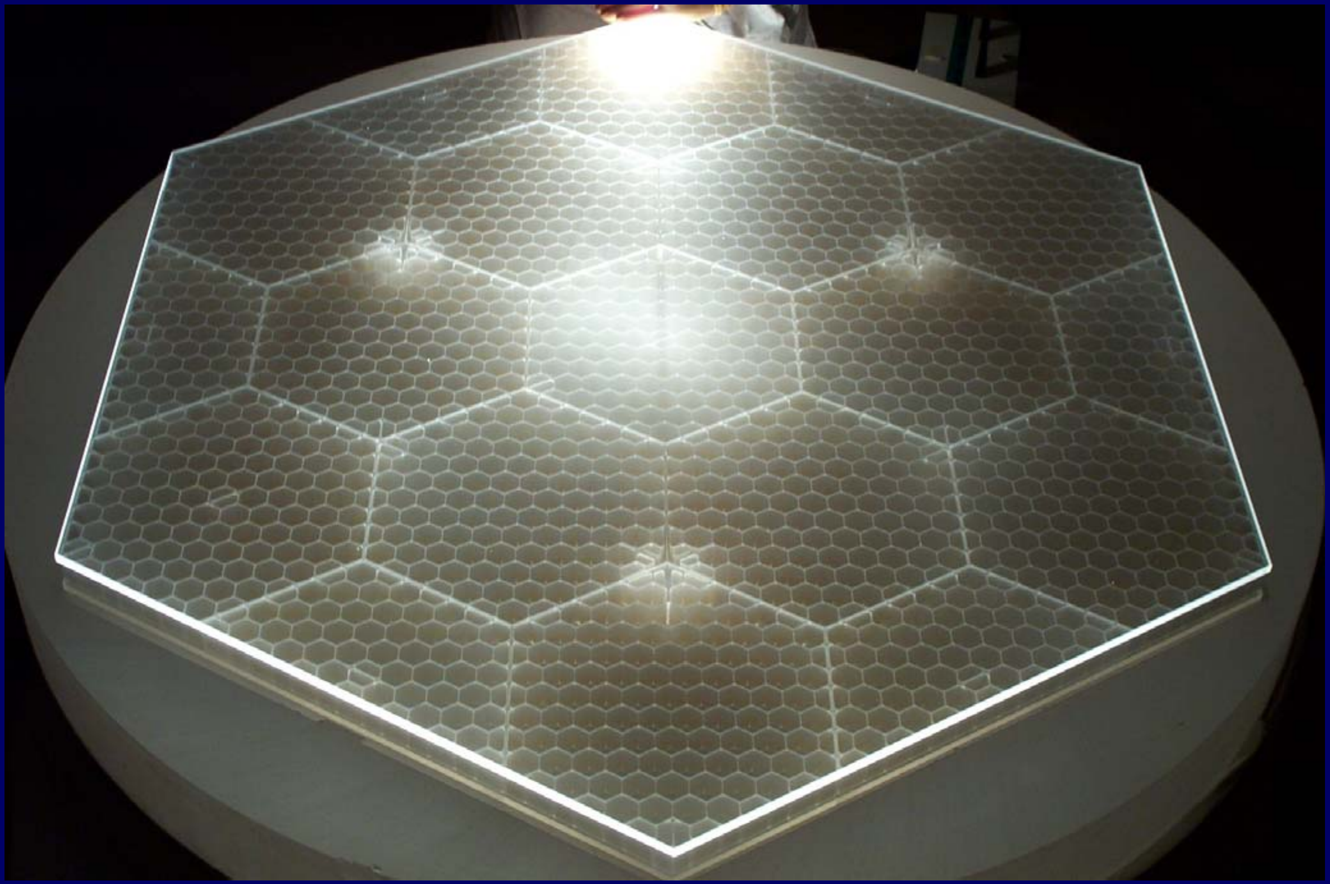
Advances in Rapid Fabrication of Aspheric Optics - Post AMSD



David Strafford & Brian Charles

Precision Optics

Eastman Kodak Company

Rapid Fabrication of Aspheric Optics

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- Requirements for Rapid Aspheric Mirror Fabrication
- Post-AMSD advances
- Work done on the AMSD-1 mirror

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Rapid Fabrication of Aspheric Optics

Process requirements

- Efficient removal of:
  - Global figure errors
  - Mid-spatial frequency errors
  - Surface roughness
  - SSD
- Compatible with:
  - High departure aspheres
  - On- and off-axis aspheres
  - Ultralightweight mirrors
  - Non-round aperture mirrors
  - Multiple materials
  - Mirrors with minimal or no edge relief

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Processing Off-Axis Aspheres

Stressed Lap

Tool Fit is ideal
Mirror Stress is eliminated

Stressed Mirror

Tool Fit is ideal
Mirror Stress is a concern

Small Tool Processing

Tool size limited by aspheric departure
Tool size limits errors that can be smoothed
Edge Effects Occur
Fabrication cycles are long

Processing Aspheric Optics

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- **Tool motion over an aspheric surface results in an aspheric mismatch**
- **Efficient smoothing of high and mid spatial frequency errors requires tool fit**

Kodak has invested in a solution

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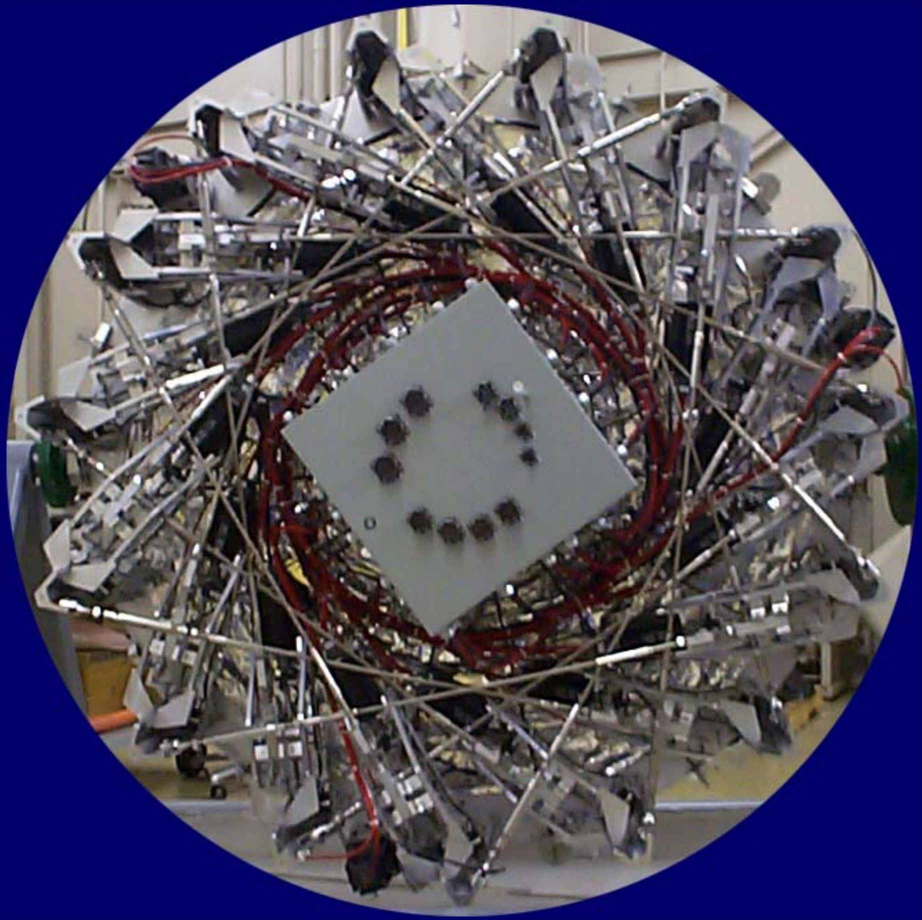
Kodak Active Lap

Kodak's Active lap is precisely deformed to fit the aspheric surface at all times on off-axis aspheres



Kodak's Active Lap Process

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- Rapidly removes surface roughness and SSD
- Removes high spatial frequency errors extremely efficiently
- Eliminates edge artifacts
- Corrects errors without reliance on metrology
- Compliments our proven technologies: CNC Aspherization, CCSTG/P, ION Figuring

Active Lap Demonstration Parts

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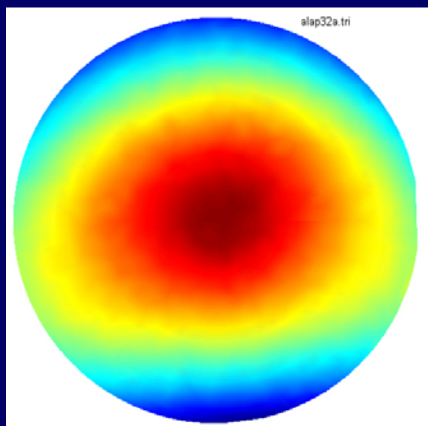
Off-axis parabolic segments with a RoC=10m and an offset from the PV of 1.4 m

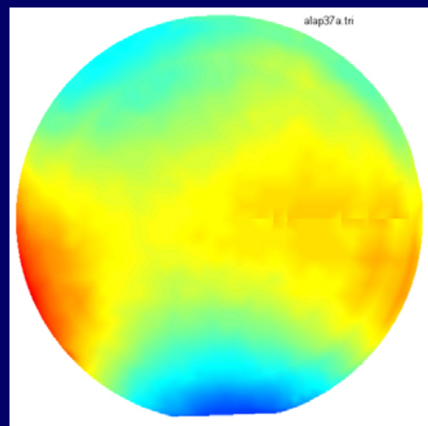
Part 1: Older ‘lightweight’, 1.1m diameter - Used to debug the machine

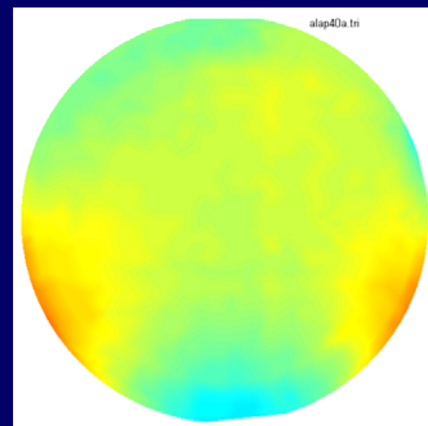
Part 2: 15 Kg/m^2 lightweight optic, 1.4m point to point hexagon, 800 HeNe waves of aspheric departure

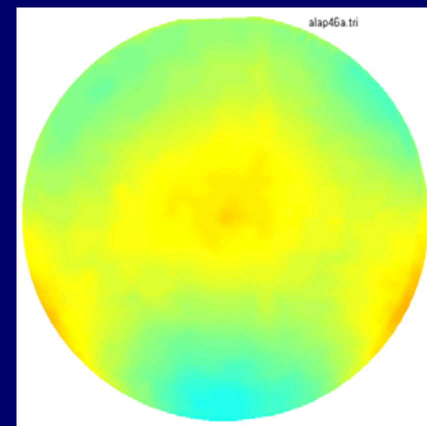
Active Lap Results- Grinding

Mirror 1 grinding results:









P-V: 42.5 um
Rms: 9.0 um

P-V: 30.5 um
Rms: 4.6 um

P-V: 17.7 um
Rms: 2.4 um

P-V: 13.6 um
Rms: 2.4 um

Active Lap results: Pre-Active Lap Grinding

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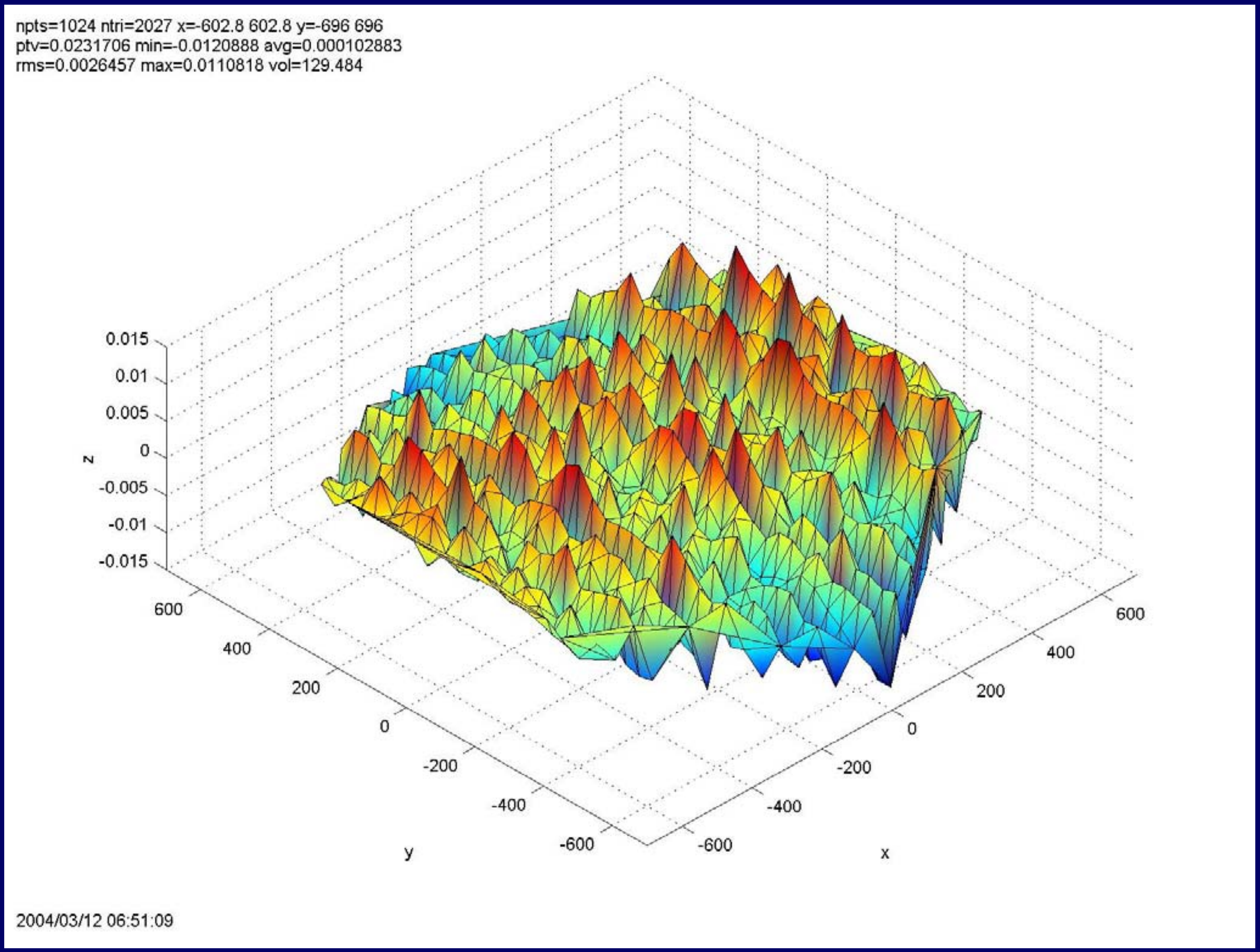

P-V: 23.2 um
Rms: 2.6 um

Mirror 2 (15 Kg/m^2 lightweight)

Active Lap Results-Removal of CNC residual HSF errors

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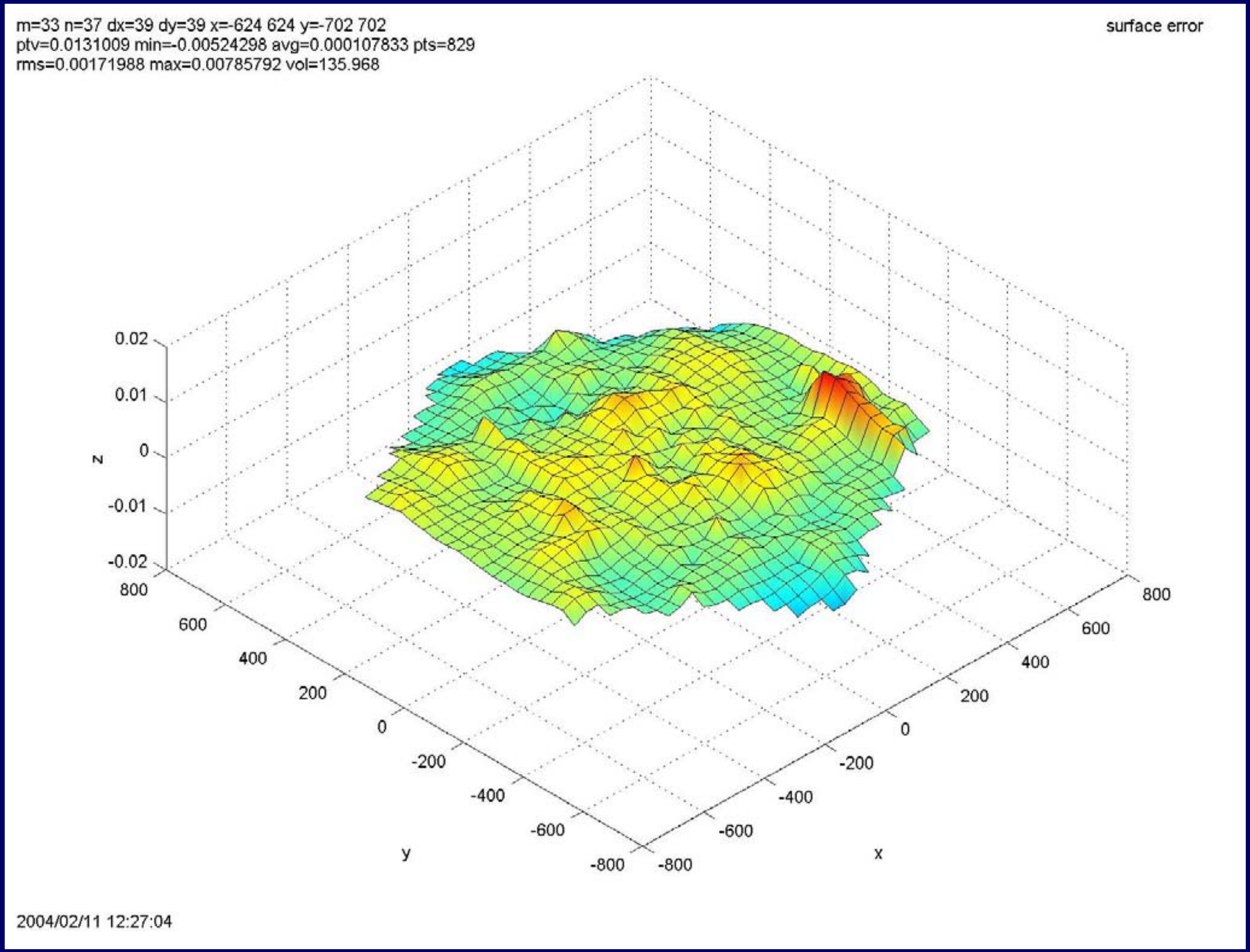
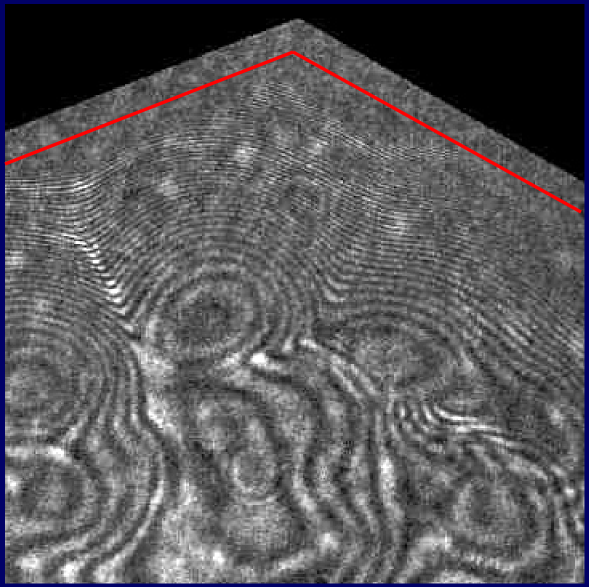


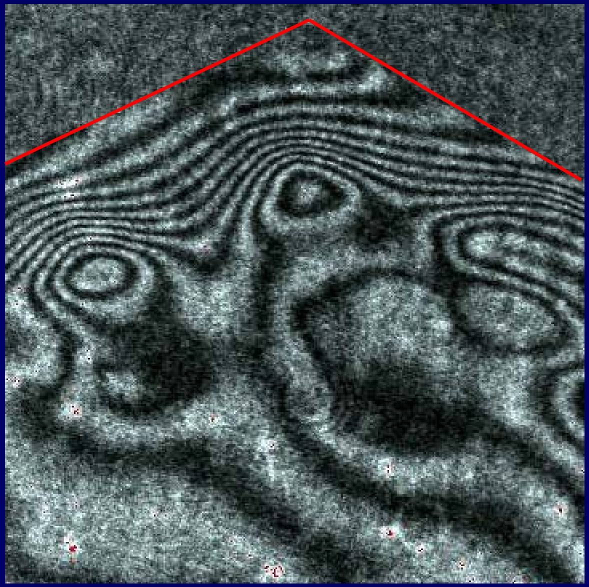
P-V: 13.1 um
Rms: 1.7 um

15 Kg/m^2 lightweight after a small amount of Active Lap processing

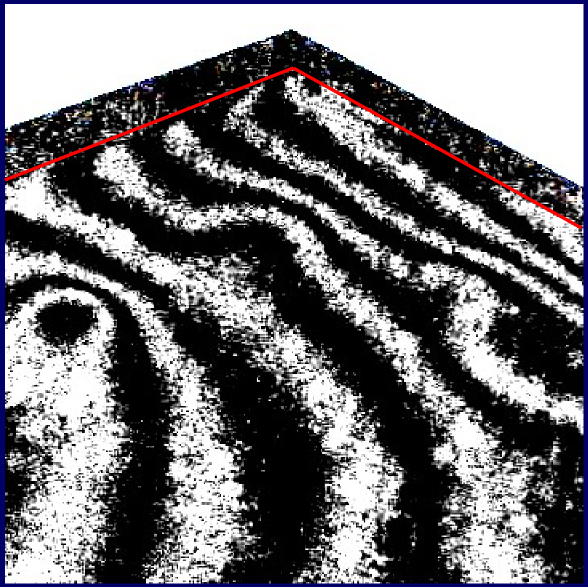
Active lap results- Edge Control in Polish



•Edge is not captured interferometrically
•Very significant edge artifacts



•Edge is captured
•Edge artifacts significantly reduced



•Edge is captured
•Edge artifacts eliminated
•Part is ready for ion figuring

Active lap controls edge figure and removes mid-spatial frequency errors without relying on accurate metrology

Active lap results- PSD reductions

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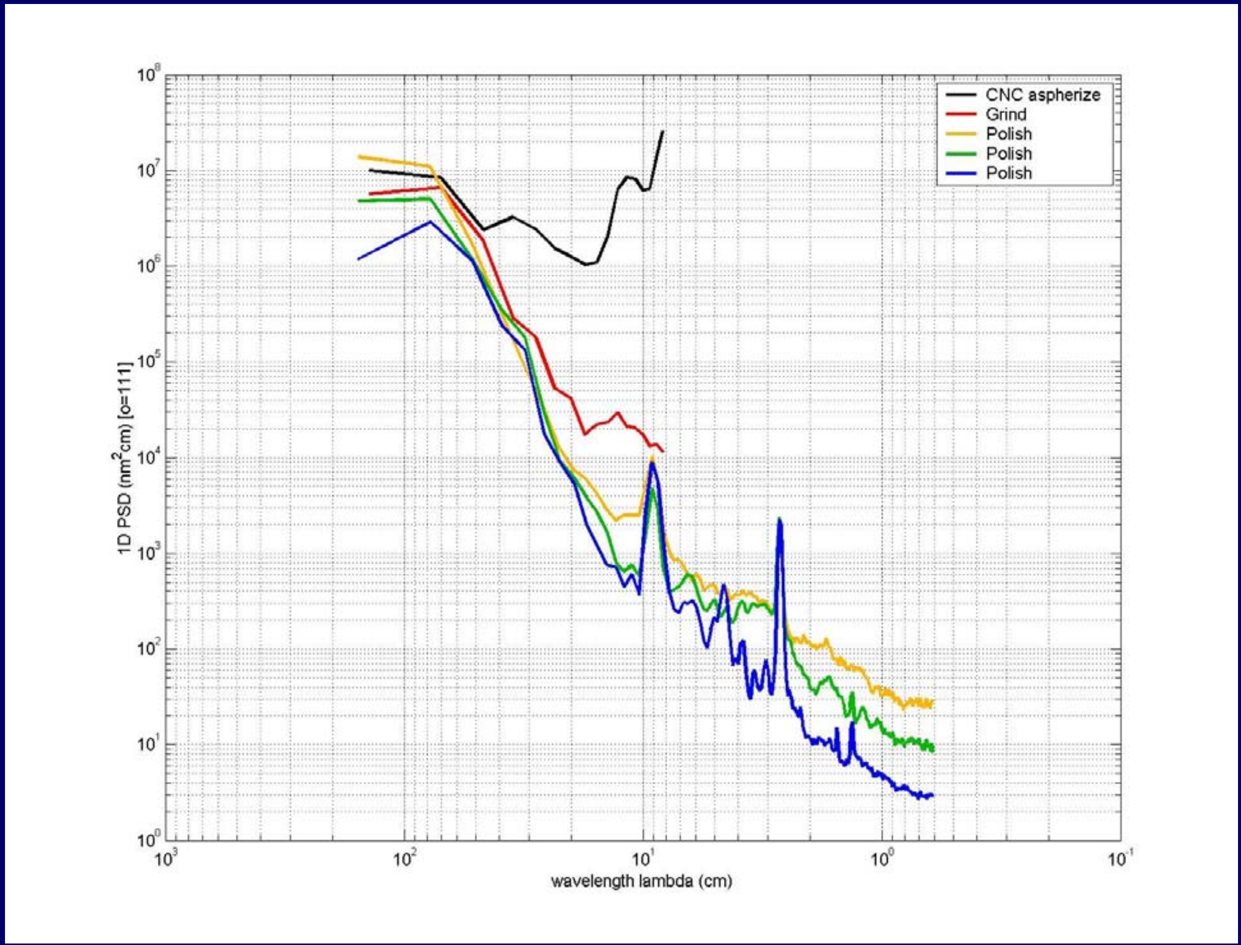

PSD improved by 5 orders of magnitude in some areas

Active lap allows rapid fabrication of high quality, high departure aspheric optics

Process Highlights

Kodak's Active lap demonstrated:

- **Efficient removal of mid and high spatial frequencies**
- **Excellent figure at the edges of non-round apertures**
- **Compatibility with ultra-lightweight mirrors**
- **Excelent performance on off-axis high departure segments**

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Summary

Eastman Kodak continues to fund, develop and implement key technologies needed to efficiently fabricate the next generation mirror designs